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Hepaticae of Puerto Rico

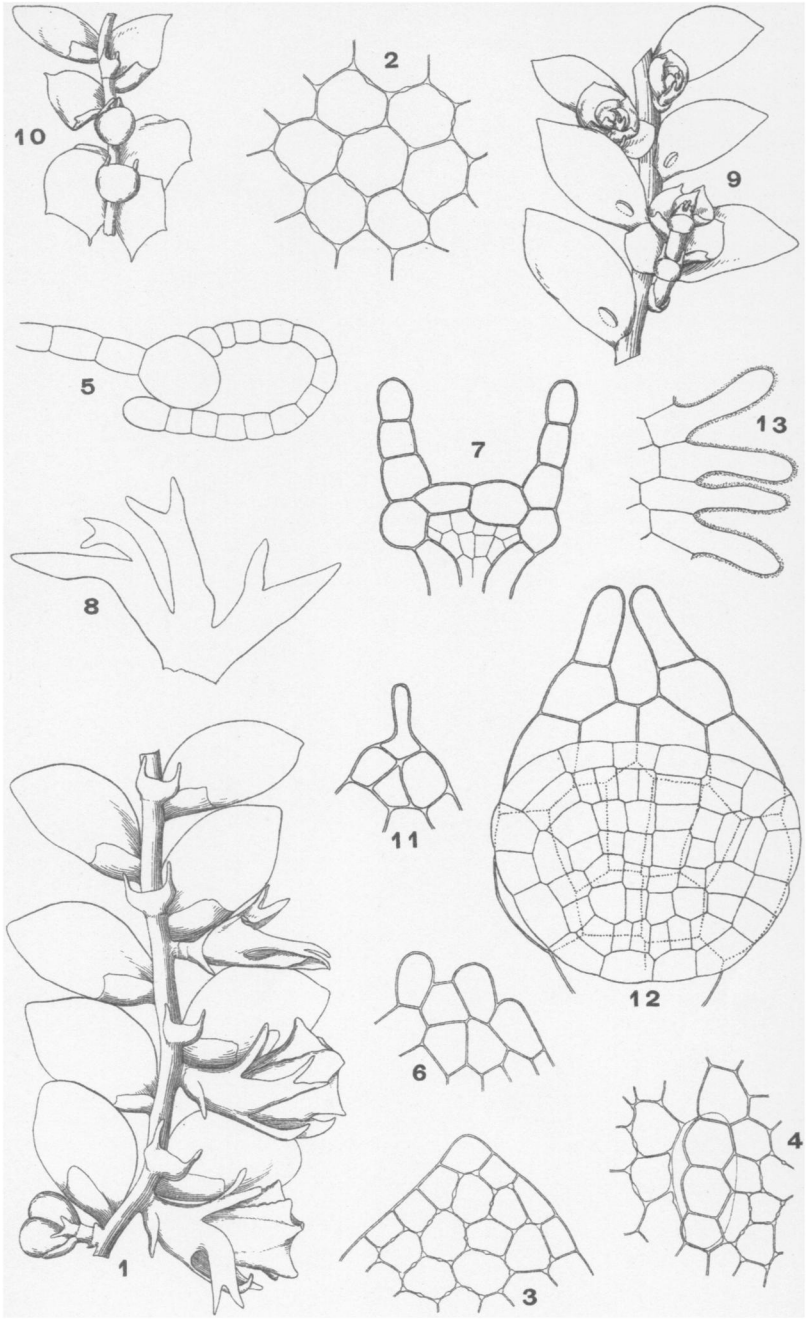
I. THE SPECIES OF LEPTOLEJEUNEA, INCLUDING AN ACCOUNT OF THEIR VEGETATIVE REPRODUCTION

BY ALEXANDER W. EVANS

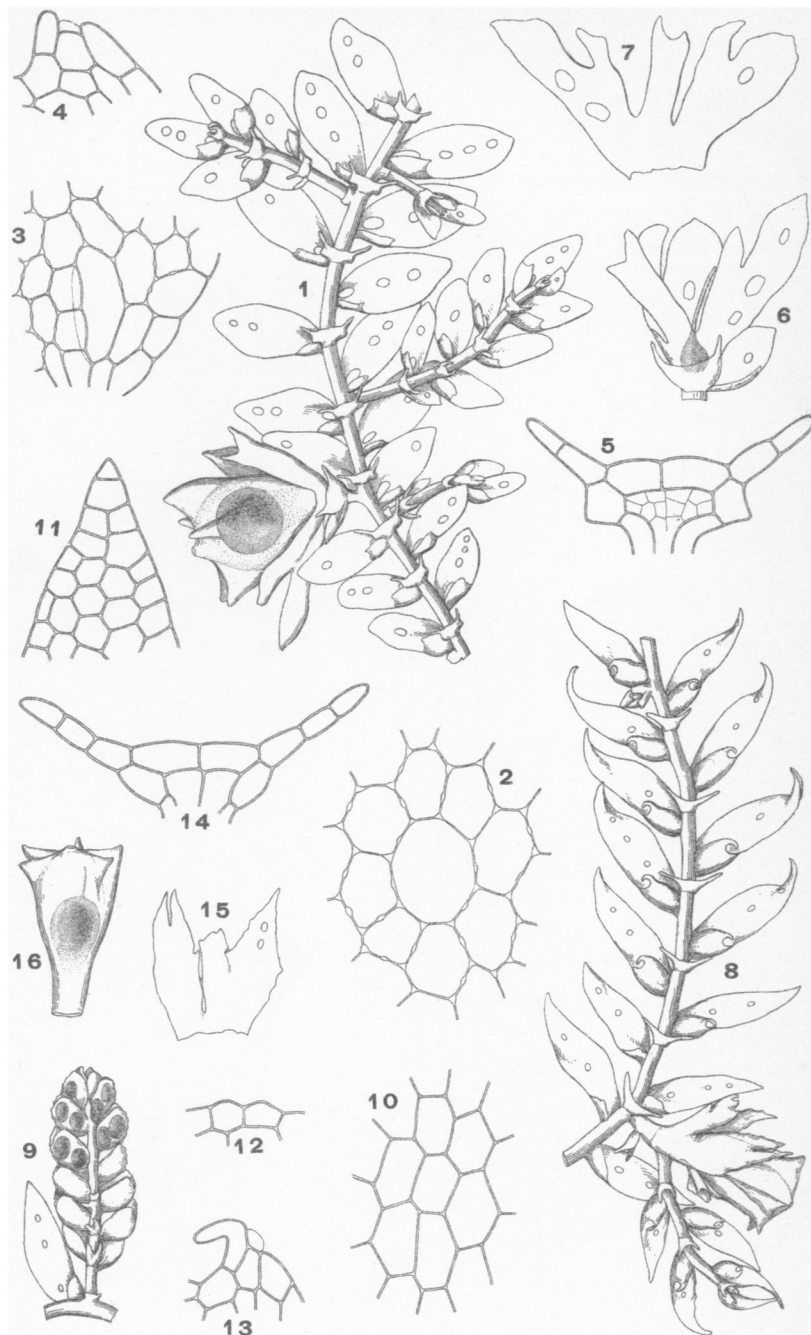
(WITH PLATES 23-25)

The genus *Leptolejeunea* is composed of minute tropical species which occur almost invariably on living leaves. A few of the species grow on ferns or on hairy plants, but most of them prefer the smooth and glossy evergreen leaves of trees and shrubs. They confine themselves to the upper surface of the leaves and at first form circumscribed patches, which are clearly defined. As the plants grow older the patches become confluent and lose their distinct outlines. The sterile axes of *Leptolejeunea* together with their leaves are at first very closely appressed to the matrix, but some of the later branches are ascending and those bearing perianths are suberect. The plants, however, never become densely matted together as is usual in the Lejeuneae.

The genus has several peculiarities in common with *Drepanolejeunea*. The underleaves for example are essentially the same in both and afford a convenient character for distinguishing them from other minute Lejeuneae. These underleaves are commonly minute even for the size of the plant and are built up in a very regular way. We can distinguish in them two slender divisions and a basal portion, the latter consisting of a central rhizoid-bearing region surrounded (except at the base) by a single row of marginal cells. The basal portion is usually in the form of a trapezium and is attached to the axis by the shorter of its parallel sides. In some species it is more nearly rectangular and is then abruptly contracted just above the base. From the upper angles of this basal portion arise the two filiform or subulate divisions, which are sometimes composed of a single row of cells throughout and are sometimes two or three cells wide in the lower part. The divisions vary from suberect to widely spreading and in certain species form an angle of 180° or more with each other. In the

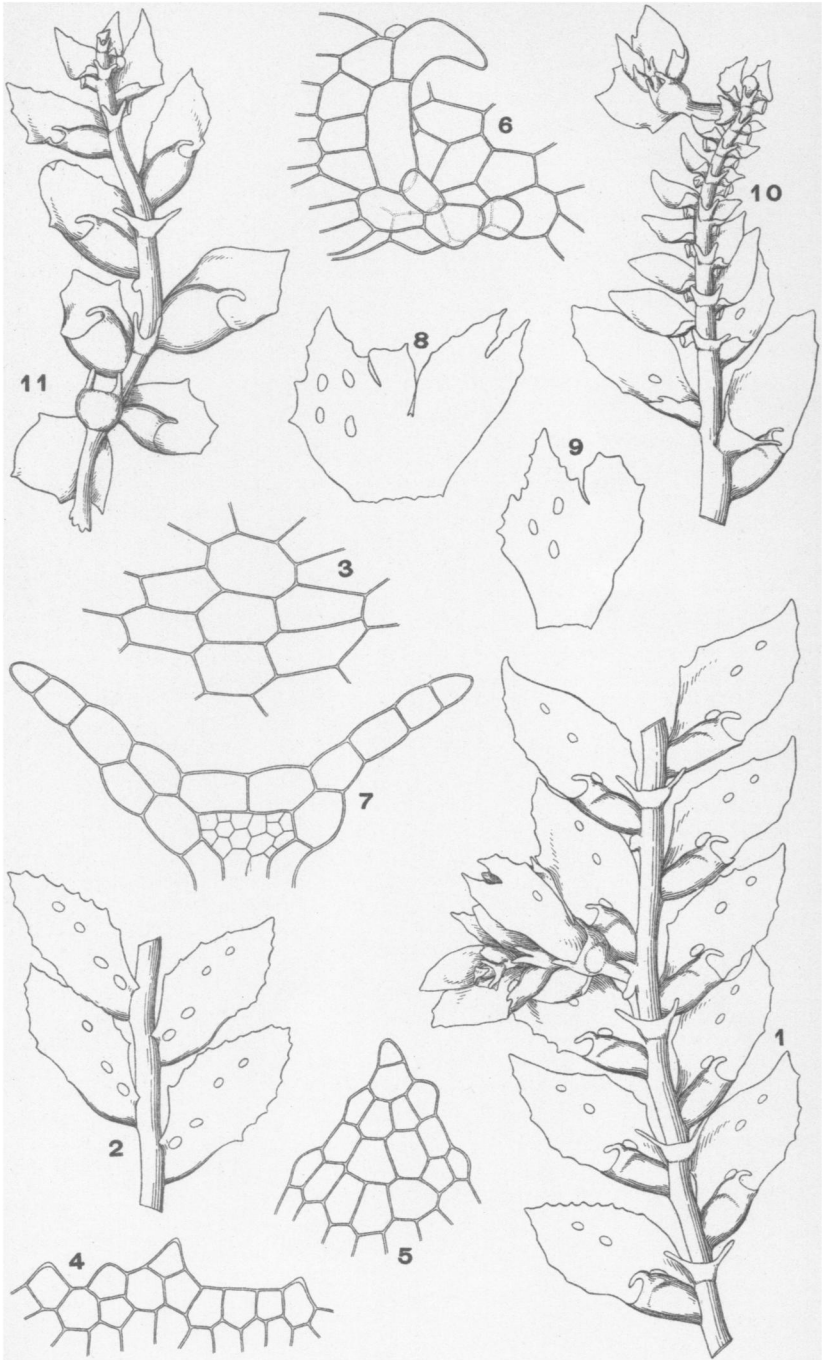


LEPTOLEJEUNEA EXOCELLATA (Spruce) Evans.



LEPTOLEJEUNEA ELLIPTICA (Lehm. & Lindenb.) Schiffn.

LEPTOLEJEUNEA STENOPHYLLA (Lindenb. & Gottsche) Schiffn.



LEPTOLEJEUNEA HAMULATA (Gottsche) Schiffn.

HELIOTYPE CO.. BOSTON.

latter case the upper boundary of the underleaf is a straight or slightly convex line. The number of cells in the basal portion, the number of cells in the divisions and the angle which the divisions form with each other vary within very narrow limits for a given species and are of much value in distinguishing between closely related plants. The rhizoids to which the underleaves give rise are numerous and of the usual type. They consist of simple or branched projections from the median cells of the basal portion and are not themselves divided into cells. The rhizoids secrete a gelatinous substance by means of which they attach the hepatic to its substratum. In a few species of *Drepanolejeunea* an underleaf sometimes develops a small, sucker-like disc, from which the rhizoids develop secondarily. Similar discs occur on the underleaves of *Odontolejeunea** and also on the first underleaves of the leafy propagula in both *Leptolejeunea* and *Drepanolejeunea*.

In the position of the ♀ inflorescence and in the general characters of the perianth, *Leptolejeunea* also agrees with *Drepanolejeunea*. The ♀ inflorescence is borne on an extremely short branch, which in some species is simple and in others gives rise to a single innovation. With the exception of the perichaetial bracts and bracteoles the leaves on the ♀ branch are abnormally developed or rudimentary, and are commonly reduced to a single side-leaf and an underleaf. The perianth is dilated and sharply five-keeled in the upper part, and the keels, with rare exceptions, extend outward, and often slightly upward, as distinct projections or horns.

The most reliable differences between the two genera are to be found in the shape of the leaves and in the characters drawn from the keels and horns of the perianths. In *Leptolejeunea* the leaves are gradually dilated from a narrow base and are rhombic, ovate, or lanceolate in outline; their apices, although sometimes acute, are scarcely acuminate and are usually plane. In *Drepanolejeunea* the leaves are abruptly dilated from a still narrower base, and are more or less triangular in outline, their apices are long and slender and usually reflexed. In *Leptolejeunea* the keels and horns of the perianth are smooth or nearly so, while in *Drepanolejeunea*, they

* Cf. Spruce, Hep. Amaz. et And. 142. 1884. Also Goebel, Pflanzenbiologische Schilderungen, 1: 161. f. 66. 1889.

are rough and often spinose. In *Leptolejeunea* also the leaves are usually ocellate and the inflorescence autoicous, while in *Drepanolejeunea*, the leaves are rarely ocellate and the inflorescence is usually dioicous. It must be admitted, however, that there are species which it is difficult to assign definitely to either genus, and in such cases we must rely upon a combination of characters rather than upon any single generic difference.

Four species of *Leptolejeunea* are now known from Puerto Rico, all of which are widely distributed in the American tropics. The commonest of these is probably *L. elliptica*, which has already been recorded by Stephani.* The range of this abundant species extends through the islands of the Pacific into the East Indian archipelago.

***Leptolejeunea exocellata* (Spruce)**

Lejeunea (*Lepto-Lejeunea*) *exocellata* Spruce, Hep. Amaz. et And. 195. 1884.

Pale green, becoming brownish upon drying; stems 0.05 mm. in diameter, closely adherent to substratum, once to thrice pinnate with widely spreading branches but less copiously branched than the preceding species: leaves distant, the lobe widely spreading, plane or nearly so when moist, appressed to substratum, ovate to obovate, 0.45 mm. long, 0.25 mm. wide, attached by a very short, oblique line of insertion, margin entire or nearly so, antical margin not arching across axis, apex obtuse to subacute; lobule oblong-rhomboidal, inflated, 0.14 mm. long, 0.09 mm. wide, keel slightly arched or almost straight, usually continuous with postical margin of lobe, roughened from projecting cells, free margin plane, appressed to basal ocellus of lobe, bicrenulate at the apex, then passing by a straight line or by a lunulate sinus to end of keel: leaf-cells thin-walled, plane or nearly so, averaging $15\ \mu$ in diameter at edge of lobe and $19\ \mu$ in the middle and at the base, trigones and intermediate thickenings minute but usually distinct, never confluent; basal ocellus, the only one present, $50\ \mu$ long, $27\ \mu$ wide, projecting postically and forming a cylindrical water-sac with the plane lobule, usually overlapped and almost covered over by adjacent cells of lobe: underleaves distant with erect or

* Hedwigia, 27: 285. 1888.

obliquely spreading, filiform divisions, each consisting of 3 or 4 cells in a single row, basal portion of underleaf rectangular or tapezoidal, 0.05 mm. long, 0.07 mm. wide, abruptly narrowed at the base, radicelliferous region surrounded by 6 marginal cells, 3 on each side, basal marginal cells curved inward, second marginal cells forming the rounded lower angles of the basal portion, third marginal cells meeting in the middle and giving rise at their junction with the second cells to the filiform divisions of the underleaf: inflorescence autoicous: ♀ inflorescence borne on a very short branch without innovation; leaf at base of branch smaller than ordinary leaves, the lobe ovate to rotund, the lobule reduced to a single row of cells connate with the lobe; underleaf at base of branch broadening from a narrow base, bifid about one half with subulate lobes and a broad lunulate sinus; bracts suberect or obliquely spreading, scarcely complicate, unequally bifid with narrow, long-pointed lobes and lobules, the lobes 0.45 mm. long, 0.07 mm. wide, margin entire; bracteole connate on both sides at the base, linear, shortly bifid with subacute divisions and sinus, margin entire, 0.35 mm. long, 0.07 mm. wide above connate base; perianth somewhat exserted, oblong or obconical from a narrow base, broad at the apex and with a short beak, 0.5 mm. long, 0.45 mm. wide in upper part, terete below, sharply five-keeled above, the keels extending upward and outward as acute or truncate horns, smooth or slightly roughened near the apex: or inflorescence usually occupying a short branch, rarely terminal on a leading branch; bracts usually in 2 or 3 pairs, imbricated, strongly inflated, shortly and subequally bilobed with obtuse divisions, keel crenulate or denticulate from projecting cells; bracteoles present at base of spike, bifid about one half with subulate lobes and obtuse or subacute sinus; antheridia in pairs: mature sporophyte not seen (*pl.* 23).

On living leaves. Between Cayey and Aibonito, *Heller* (568, 569); near Mayaguez, *Heller* (4566 *p. p.*, 4567 *p. p.*); Cayey, *Evans* (70a *p. p.*).

LEPTOLEJEUNEA ELLIPTICA (Lehm. & Lindenb.) Schiffn.

Jungermannia elliptica Lehm. & Lindenb.; Lehmann, Pugillus, 5: 13. 1833.

Lejeunea elliptica Lehm. & Lindenb.; G. L. & N. Syn. Hep.
403. 1845.

Colura elliptica Trevis, Mem. r. Ist. Lomb. III. 4: 402. 1877.

Lejeunea (*Lepto-Lejeunea*) *elliptica* Spruce, Hep. Amaz. et And.
194. 1884.

Lepto-lejeunea elliptica Schiffn. Die nat. Pflanzenfam. 11³: 26.
1893.

Pale green, becoming brownish or blackish upon drying; stems 0.04 mm. in diameter, closely adherent to substratum, once to thrice pinnate with widely spreading branches: leaves distant, the lobe widely spreading, plane or nearly so when moist, appressed to substratum, oblong-ovate to oblong-lanceolate, 0.35 mm. long, 0.18 mm. wide, attached by a very short oblique line of insertion, margin entire, antical margin not arching across axis, apex rounded, obtuse or rarely subacute; lobule ovate, inflated, 0.01 mm. long, 0.08 mm. wide, keel slightly arched or almost straight, usually continuous with postical margin of lobe, roughened from projecting cells, free margin plane and appressed to basal ocellus of lobe, bicrenulate at apex, then passing by a lunulate sinus to end of keel; lobule often poorly developed; leaf-cells thin-walled, plane or nearly so, averaging 13 μ in diameter at edge of lobe and 23 μ in the middle and at the base, trigones and intermediate thickenings minute but distinct, never confluent; ocelli 2 to 5 in number, arranged in a median, interrupted line, basal ocellus larger than the others, 45 μ long, 25 μ wide, projecting postically and forming a cylindrical water-sac with the plane lobule, sometimes partially overlapped by adjacent cells of lobe: underleaves distant with widely spreading, filiform divisions, each consisting of 2 or 3 cells in a single row, the cells longer than in *L. exocellata* and with less bulging walls, basal portion broadly rectangular or trapezoidal, 0.04 mm. long, 0.07 mm. wide, abruptly narrowed at the base, radicelliferous region surrounded by 6 marginal cells as in the preceding species but with the second marginal cells sharply angular instead of rounded: inflorescence autoicous or dioicous: ♀ inflorescence borne on a very short branch without innovation; leaf and underleaf at base of branch similar to those of *L. exocellata*; bracts obliquely spreading, scarcely complicate, shortly and unequally bifid, the lobe oblong to obovate, acute to rounded at the

apex, sometimes indistinctly apiculate, entire, 0.4–0.5 mm. long, 0.08–0.14 mm. wide, lobule ovate to ligulate, obtuse; bracteole connate on both sides at the base, linear, shortly bifid with obtuse sinus and obtuse or acute divisions, margin entire, 0.25 mm. long, 0.07 mm. wide above connate base; perianth slightly exserted, obconical from a narrow base, broad at the apex and with a short beak, 0.4 mm. long, 0.35 mm. wide, terete below, sharply fine-keeled above, the keels extending upward and outward as acute or truncate horns, smooth or slightly roughened near the apex; or inflorescence usually occupying a short branch, rarely terminal on a leading branch; bracts and bracteoles as in *L. exocellata*; antheridia in pairs: spores oblong, greenish, with a thick, brownish, minutely verruculose wall, averaging 23μ in short diameter (*pl.* 24, *f.* 1–7).

On living leaves. First collected by *Sintenis* (45, 136); 14 miles south of San Juan, *Heller* (678, 680); near Mayaguez, *Heller* (4566 *p. p.*, 4567 *p. p.*); Cayey, *Evans* (70a *p. p.*).

L. exocellata and *L. elliptica* are very closely related species. They are not only strikingly similar in appearance but are likely to grow mixed together on a single leaf, and for these reasons they have been much confused by students of the hepaticae. Even Spruce, who first recognized the first species, considered its validity as somewhat doubtful and suggested that it might perhaps be looked upon as a variety of *L. elliptica*.

According to its author, *L. exocellata* may be distinguished from *L. elliptica* by the following differences: the plants are a little larger, their leaves are sometimes narrowed at the base (*i. e.*, obovate-lanceolate) and are constantly *exocellate*, the leaf-cells are more indistinct and with somewhat thickened walls, the infrafloral underleaf is conspicuously pentagonal and bicuspidate, the perichaetial bracts are narrower and the perianth is larger.

Unfortunately several of these differences are not to be relied upon, and this applies particularly to those which concern the leaf-cells. In his full descriptions of the two species in question, Spruce states that the cells of *L. elliptica* are “valde leptodermes,” while those of *L. exocellata* are “intus sinuatae, parietibus, subincrassatis.” As a matter of fact the cell-walls are very thin in both species but show almost invariably minute and distant trigones

and intermediate thickenings. These are a trifle larger in *L. elliptica* than in *L. exocellata*, but the difference is not at all striking. The species of *Leptolejeunea* when dried do not always assume their natural appearance upon the addition of water. Even boiling water is not always effective, and it is sometimes necessary to treat them with potash solution or some similar reagent before we can gain an accurate idea of their cells. This is probably one reason why the cell-structure is not always accurately described.

The absence of ocelli in the leaves of *L. exocellata* is emphasized by Spruce, and it is from this supposed character that the species derives its name. There is present, however, at the base of the lobe a large hyaline cell about three times as long as the neighboring cells. This cell, which would naturally be interpreted as an ocellus, occurs not only in Puerto Rico specimens, but also in South American specimens distributed by Spruce himself. The ocellus is more or less overlapped by the adjacent part of the lobe on the side toward the keel. This part is distinctly convex, and we can see the ocellus clearly only by focussing through the cells which lie over it (*pl.*, *f.* 4). Sometimes the overlapping goes so far that the ocellus looks as if it were a foreign body inside the water-sac, and possibly it has been so interpreted. In reality it takes direct part in the formation of the water-sac. It is not only longer than the neighboring cells, but greater in diameter and projects considerably beyond them toward the substratum. Here it comes into contact with the free edge of the lobule, which remains plane or nearly so (*f.* 5), and in this way a cylindrical sac is formed open only at one end. The capacity of the sac is of course increased by the convexity of the lobe between the ocellus and the keel. A similar ocellus occurs in *L. elliptica*, but it is usually less concealed by overlapping cells. Except for this basal ocellus the leaf of *L. exocellata* is truly "exocellate," and lacks the interrupted row of ocelli, which is characteristic of *L. elliptica*.

The differences in the subfloral underleaves, as noted above, do not seem to be constant. It is sometimes difficult to make out these structures at all on account of the numerous rhizoids which they bear, but when well developed they are essentially alike in the two species.

The remaining differences mentioned by Spruce seem to be

trustworthy. It may be added to these that the leaves of *L. elliptica* are usually from 8 to 12 cells broad, while those of *L. exocellata* are from 12 to 15 cells. The underleaves of the latter species also are rounded below instead of angular, and their slender divisions spread less widely and have more bulging cells than in *L. elliptica*.

LEPTOLEJEUNEA STENOPHYLLA (Lindenb. & Gottsche) Schiffn.

Lejeunea stenophylla Lindenb. & Gottsche; G. L. & N. Syn. Hep. 769. 1847.

Colura stenophylla Trevis, Mem. r. Ist. Lomb. III. 4: 402. 1877.

Lejeunea (*Lepto-Lejeunea*) *stenophylla* Steph. Hedwigia, 29: 96. 1890.

Leptolejeunea stenophylla Schiffn. Engler's Bot. Jahrb. 23: 596. 1897.

Pale green, becoming yellowish or brownish upon drying; stems 0.035 mm. in diameter, closely adherent to substratum, irregularly once or twice pinnate with widely spreading branches: leaves distant, the lobe obliquely spreading, plane or somewhat revolute along antical margin, straight or upwardly curved near the apex, lanceolate, 0.5 mm. long, 0.13 mm. wide, somewhat narrowed toward the base and attached by an almost longitudinal line of insertion, margin entire or very slightly crenulate or denticulate from projecting cells, apex acute or short acuminate; lobule ovate, strongly inflated, 0.12 mm. long, 0.09 mm. wide, keel slightly arched, smooth or nearly so, usually continuous with postical margin of lobe, free margin plane or strongly involute too, or including the apex, then lunulate to end of keel, apex formed by a single cell so strongly curved as to almost touch the end of the keel, forming in this way a circular opening into the water-sac; lobule often poorly developed; leaf-cells thin-walled and without trigones, plane or nearly so, averaging $17 \times 12 \mu$ at the edge of lobe and $20 \times 12 \mu$ in the middle and at the base; ocelli 1 to 4, forming an interrupted median row, scarcely distinguishable from the other cells: underleaves distant, 0.04 mm. long, 0.15 mm. wide, with widely spreading filiform divisions, each consisting of (2 or) 3 cells in a single row, basal portion of underleaf broadly trapezoidal, cuneate at the base, the lateral margins continuous with the divisions, radicelliferous region surrounded by 6 marginal cells: inflorescence dioicous: ♀ inflorescence borne on a very short branch, innovating on one side with

a short, simple and sterile innovation ; bracts obliquely spreading, scarcely complicate, unequally bifid, the lobe ovate, acute or acuminate, 0.35 mm. long, 0.12 mm. wide, margin irregularly denticulate, lobule varying from sharp-pointed to truncate, 0.17 mm. long, 0.009 mm. wide, margin as in lobe ; bracteole more or less connate on both sides at the base, narrowly ovate, 0.35 mm. long, 0.1 mm. wide, bifid about one third with narrow, erect sharp-pointed lobes, and a narrow sinus, margin denticulate ; perianth somewhat exserted, obconical, gradually narrowed toward base, 0.6 mm. long, 0.35 mm. wide, broad and truncate at the apex, and very shortly beaked, terete below, sharply 5-keeled above, the keels extending outward as triangular horns, acute to truncate at the apex, smooth or slightly roughened from projecting cells : or inflorescence occupying a short branch or terminal on a leading branch ; bracts usually in 6 to 10 pairs, imbricated, strongly inflated, shortly and subequally bifid, the lobe obtusely to acutely pointed, lobule blunter, keel strongly arched, cells in upper part forming a very narrow denticulate wing : bracteoles present at base of spike, small, bifid about one half, with erect-spreading pointed lobes and obtuse sinus : antheridia in pairs : mature sporophyte not seen (*pl. 24, f. 8-16*).

On living leaves. Cayey, *Evans* (70b).

The specimens of *L. stenophylla* from Puerto Rico agree very closely with those distributed in *Hepaticae Cubenses Wrightianae*. The latter were determined by Gottsche and the determination has since been confirmed by Schiffner. The species has also been reported from Mexico (the type-locality) and from Bolivia.

L. stenophylla is very distinct from the two preceding species. It differs from them in its leaves, which are narrower and much more sharply pointed ; in its leaf-cells, which lack local thickenings ; in the absence of a large basal ocellus ; and in the presence of a subfloral innovation. Its underleaves also are very different in shape and are never angular below their spreading divisions. In its lobule, the apex of which is formed by a single strongly curved cell, the species differs not only from *L. elliptica* and *L. exocellata* but from nearly all the other members of the genus, and approaches in this respect several species of *Drepanolejeunea*.

LEPTOLEJEUNEA HAMULATA (Gottsche) Schiffn.

Lejeunea hamulata Gottsche ; Wright, *Hep. Cubenses* ; Schiffn. Engler's Bot. Jahrb. **23** : 587. 1897 (as synonym).

Leptolejeunea hamulata Schiffn. *l. c.*

Brownish-green, growing in thin, irregular patches: stems prostrate, 0.06 mm. in diameter, irregularly pinnate, the branches widely spreading, those bearing propagula microphyllous: leaves distant to contiguous, the lobe obliquely spreading, plane or with slightly revolute margins near the apex, ovate to ovate-lanceolate, distinctly narrowed toward the base, 0.6 mm. long, 0.25 mm. wide, attached by an almost longitudinal line of insertion, margin denticulate except in basal region, the teeth usually projections of single cells, rarely composed of from 1 to 3 cells, antical margin somewhat more convex than postical, apex acute, tipped with a single cell or with 2 superimposed cells; lobule oblong, 0.2 mm. long, 0.14 mm. wide, inflated toward base and along keel, plane and appressed to lobe in outer part, keel slightly arched, forming an almost continuous line with postical margin of lobe, free margin involute toward base, passing beyond apex by a lunulate sinus to end of keel, apex formed by a single, strongly curved cell separated by a slight indentation from the inner part of the free margin; cells of lobe plane or nearly so, averaging $14\ \mu$ at the edge, $23 \times 13\ \mu$ in the middle and at the base, thin-walled throughout or more rarely with indistinct and more or less confluent local thickenings; ocelli indistinct, but present in well-developed leaves, varying in number from 1 to 6, usually 4, arranged in an interrupted longitudinal row, those near the base of lobe measuring $35 \times 23\ \mu$, those in outer part averaging $23 \times 16\ \mu$: underleaves distant, basal portion trapezoidal in outline, often abruptly contracted at base, 0.05 mm. long, 0.09 mm. wide, marginal cells 6, the second cells more or less bulging, divisions obliquely spreading, 3 or 4 cells long, 1 or 2 cells wide at base, the cells very slightly bulging, cluster of rhizoids sometimes replaced by a sucker-like disc: inflorescence dioicous: ♀ inflorescence borne on a very short branch, innovating on one side with a short, simple and sterile innovation; underleaf at base of branch usually with a sucker-like disc; bracts erect-spreading, complicate, shortly and unequally bifid, the lobe ovate, 0.45 mm. long, 0.2 mm. wide, acute, sharply and irregularly denticulate above the middle: lobule oblong, 0.35 mm. long, 0.1 mm. wide, truncate to acute at the apex, denticulate; bracteole connate on one side, oblong-obovate, 0.4 mm. long, 0.17 mm. wide, bifid about one third with acute divisions and sinus, margin irregularly denticulate or crenulate in upper part; perianth obpyramidal, shortly rostellate, 0.55 mm. long, 0.45 mm. wide at apex, 5-keeled, the keels dilated and truncate in upper part, smooth or nearly so: ♂ inflorescence terminal on a short branch; bracts in 5 to 12 pairs, imbricated, strongly inflated, shortly bifid, the lobe obtuse, the lobule rounded, margins subentire, keel strongly arched, denticulate in

outer part; bracteoles limited to base of spike, similar to ordinary underleaves, but smaller and with more erect divisions: antheridia in pairs (*pl.* 25).

On living leaves. Cayey, *Evans* (71 *p. p.*).

The Puerto Rico specimens of *L. hamulata* agree closely with those distributed in Hepaticae Cubenses. Unfortunately they show no perianths and the description of this organ as given above is taken entirely from Schiffner. In all other respects the specimens are well developed.

The close relationship which exists between the present species and *L. stenophylla* has already been commented upon by Schiffner. *L. hamulata* is the larger of the two species and differs also in its broader and less acuminate lobes with sharply denticulate margins. It must be acknowledged, however, that poorly developed specimens are sometimes difficult to determine.

In the original description of *L. hamulata* the lobule is said to be "cylindrico-convolutus apice duobus dentibus validis hamatis conniventibus foramen rotundum includentibus armatus." One of the teeth referred to is evidently the curved cell at the apex of the lobule, the other is apparently the fold at the junction of lobule and lobe. Until the lobule is flattened out by pressure this fold often resembles a tooth in a marked degree. A lobule of this character, although not unusual in *Drepanolejeunea*, is, according to Schiffner, almost unique in *Leptolejeunea*. He emphasizes it in fact as one of the most important differences between *L. hamulata* and *L. stenophylla*. It is evident, however, from a study of the Puerto Rico specimens of the latter species that a *normal* lobule is built up on essentially the same plan as in *L. hamulata*. Unfortunately normal lobules are somewhat unusual and are largely replaced by rudimentary structures in which the true lobular characters are not apparent. In the Cuban specimens normal lobules are still more infrequent but may be demonstrated by careful search.

Aside from their lobules *L. stenophylla* and *L. hamulata* resemble each other closely in their antheridial spikes, in the possession of a subfloral innovation, in their perichaetial bracts and bracteoles and apparently also in their perianths. Most of these peculiarities will distinguish them from *L. exocellata* and *L. elliptica*.

In addition to the ordinary method of reproduction, the four

Puerto Rico *Leptolejeuneae* exhibit a vegetative reproduction by means of leafy propagula. These arise just behind the leaves in the position usually occupied by normal branches. They are to be looked upon, therefore, as modified branches, the whole of the branch, with the exception of the basal sheath, taking part in the formation of the propagulum. Leafy propagula have already been noted in *Plagiochila* and in various other genera of the *Jungermanniceae*, but in all cases which have been described they have arisen directly from leaf-cells or more rarely from indefinitely situated axis-cells. Goebel * ascribes the formation of these propagula to the latent power retained by every cell of the liverwort (*i. e.*, of the gametophyte) to develop as if it were a spore—a power which is not made manifest until the plant becomes enfeebled. Propagula of this character are essentially different from those of *Leptolejeunea*, in which the reproductive bodies represent entire branches. The latter, although described for various mosses,† have not before been recorded for any of the leafy hepatics.

The modifications in structure which are exhibited by the propagula of *Leptolejeunea* are in part explicable by their function as reproductive bodies and in part by the peculiar habitat of the species, namely the smooth and glossy surface of evergreen leaves. These modifications are most pronounced in *L. exocellata* and *L. elliptica*, and the propagula of these two species, which are essentially alike, will be considered first. Instead of spreading widely as it would if it were a normal branch, a young propagulum grows toward the apex of the stem, lying above the leaves and parallel with the axis or only slightly diverging from it (*pl. 23, f. 9*). In assuming this position its axis curves abruptly near the base in such a way that the antical surface of the propagulum is turned downward, while the postical surface with its underleaves is turned upward.

The first few leaves and underleaves of the propagulum (*f. 10*) are very different from those borne on ordinary axes. The leaves, although larger than the first leaves of a normal branch, are shorter than typical leaves and are nearly as broad as long. Their

* Organographie der Pflanzen, 277. 1898.

† Cf. Correns. Unters. über die Vermehrung der Laubmoose durch Brutorgane und Stecklinge. 1899. *E. g.*, *Plagiothecium elegans*, p. 250.

lobes are strongly squarrose and are sometimes completely reflexed, so that they come to lie parallel with the axis and with their apices pointing toward the base of the propagulum. The lobules are very rudimentary and in the reflexed leaves are turned forward, in this way obliterating the keel. The modified leaves, instead of being entire like ordinary leaves, are angular-dentate with from one to three teeth, one being at the apex, and the others (when present) on the outer edge. These teeth often end in the curious rhizoid-like processes (f. 11) described by Schiffner* for *Cheilolejeunea versifolia* and for certain other hepaticae, but it is doubtful if they ever assume the function of rhizoids. As we pass from the base toward the apex of the propagulum, we find all gradations between these modified leaves and the ordinary leaves of the species.

The first two underleaves of the propagulum are perhaps even more remarkable than the leaves. They are larger than ordinary underleaves and their divisions often bend inward instead of diverging. The middle cells of the basal portion, which are more numerous than usual, do not produce rhizoids directly but develop instead, a large, orbicular, sucker-like disc (f. 12) composed of minute and closely united cells. This disc is entire on the margin and often projects slightly beyond the basal portion of the underleaf.

When a propagulum has developed several pairs of leaves, it becomes separated from the parent plant and develops into a new individual. The separation takes place at its junction with the parent-axis just within the basal sheath. The cells by which it is actually attached are few in number, often reduced apparently to a single one. These cells gradually become shriveled, and it requires very little force to tear them across and set the propagulum free. Probably in nature the force of a shower would be sufficient to bring about this result. It has already been stated that a propagulum, while still attached, lies with its underleaves turned away from the substratum. This position cannot be very stable after separation takes place, because the propagulum would rest on nothing except the edges and apices of its squarrose leaves. Probably here again the force of dripping water is sufficient to over-

* Engler's Bot. Jahrb. 23 : 598. pl. 15. f. 4. 1897.

turn it and at the same time to carry it a short distance away from its parent axis.

By means of the discs on the underleaves, which have the power in common with rhizoids of secreting a gelatinous substance, the propagulum attaches itself firmly to the substratum. Sometimes the attachment is made still firmer by rhizoids which grow out from the marginal cells of the disc (*f. 13*). In the similar discs of *Odontolejeunea* the power of developing rhizoids is possessed by all the cells of the disc, instead of by the marginal cells alone, as in these propagula. When the propagulum has thus established itself, its growing region continues to develop and produces an axis bearing normal leaves and underleaves.

The propagula of *L. stenophylla* are less highly specialized than those of the two preceding species. The branches upon which they are developed usually bear abortive leaves, consisting of a short lobe and an extremely rudimentary lobule, and the growth of these branches is soon arrested by the production of the propagula. In this species the first underleaf is larger than the succeeding ones and shows a well-developed disc. The lobes of the first and second side-leaves are squarrose and more or less toothed and the lobule of the first leaf at least is very rudimentary. The third leaf, however, and sometimes even the second, develop normal lobules, and the fourth and fifth leaves show fairly characteristic lobes.

Leafy propagula of the type just described occur also in several species of *Drepanolejeunea*. Their discovery may likewise be expected in other epiphyllous Lejeuneae and especially in those which do not develop disc-shaped gemmae.

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Explanation of Plates

The figures were drawn by the writer with the aid of the camera lucida. Most of them were prepared for reproduction by Miss Edna L. Hyatt.

PLATE 23

Leptolejeunea exocellata (Spruce) Evans. 1. Stem with two perianths, a ♀ inflorescence and a ♂ inflorescence, postical view, $\times 47$. 2. Cells from middle of lobe, $\times 425$. 3. Cells from apex of lobe, $\times 300$. 4. Cells from base of lobe, showing basal ocellus partially overlapped by adjacent cells, $\times 400$. 5. Transverse section through lobe and lobule, showing basal ocellus, $\times 300$. 6. Apex of lobule, $\times 300$.

7. Underleaf, $\times 300$. 8. Bracts and connate bracteole, $\times 67$. 9. Stems with three young propagula in various stages of development, $\times 47$. 10. Base of an established propagulum, $\times 47$. 11. Apex of one of the first leaves of a propagulum, $\times 300$. 12. Underleaf of propagulum with sucker-like disc, $\times 360$. 13. Marginal cells of disc with rhizoids, $\times 360$. Ten was drawn from a specimen collected by A. A. Heller near Mayaguez (no. 4567 *p. p.*); the other figures were all drawn from specimens collected by the writer at Cayey (no. 70a *p. p.*).

PLATE 24

Leptolejeunea elliptica (Lehm. & Lindenb.) Schiffn. 1. Part of plant with perianth, postical view, $\times 45$. 2. Cells from middle of lobe, enclosing an ocellus, $\times 400$. 3. Cells from base of lobe showing basal ocellus, $\times 280$. 4. Apex of lobule, $\times 280$. 5. Underleaf, $\times 280$. 6. ♀ branch, postical view, $\times 65$. 7. Bracts and connate bracteole, $\times 65$. The figures were all drawn from specimens collected by A. A. Heller near Mayaguez (no. 4567 *p. p.*).

Leptolejeunea stenophylla (Lindenb. & Gottsche) Schiffn. 8. Stem with perianth, postical view, $\times 45$. 9. ♂ inflorescence, postical view, $\times 45$. 10. Cells from middle of lobe, enclosing an ocellus, $\times 400$. 11. Cells from apex of lobe, $\times 280$. 12. Cells from antical margin of lobe, $\times 280$. 13. Apex of lobule, $\times 280$. 14. Underleaf, $\times 280$. 15. Bract and connate bracteole, $\times 65$. 16. Perianth, $\times 45$. The figures were all drawn from specimens collected by the writer at Cayey (no. 70b).

PLATE 25

Leptolejeunea hamulata (Gottsche) Schiffn. 1. Stem with ♀ inflorescence, postical view. 2. Part of stem, antical view. 3. Cells from middle of lobe. 4. Cells from antical margin of lobe. 5. Cells from apex of lobe. 6. Outer portion of lobule. 7. Underleaf. 8. Bract and bracteole. 9. Bract from same involucre. 10. Microphyllous branch showing a propagulum almost ready to become separated and the empty sheath of several older propagula, postical view. 11. An established propagulum, becoming microphyllous in upper part. All the figures are drawn from specimens collected by the writer at Cayey.